

The C-5 Digital Communications Processor

Dave Husak
CTO, C-Port, A Motorola Company
June 2000





C-5 DCP Network Processor

System Scaling

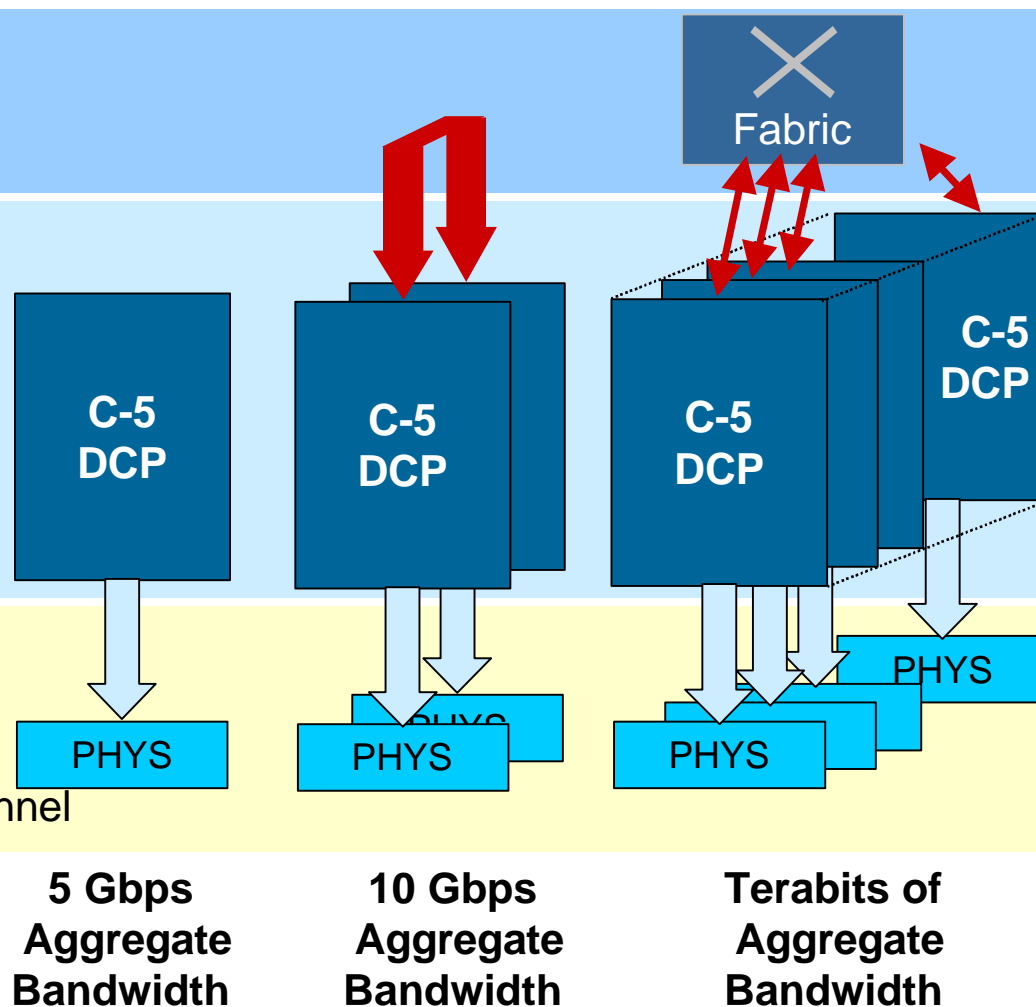
CSIX Standard
Custom Interconnects

Networking Intelligence

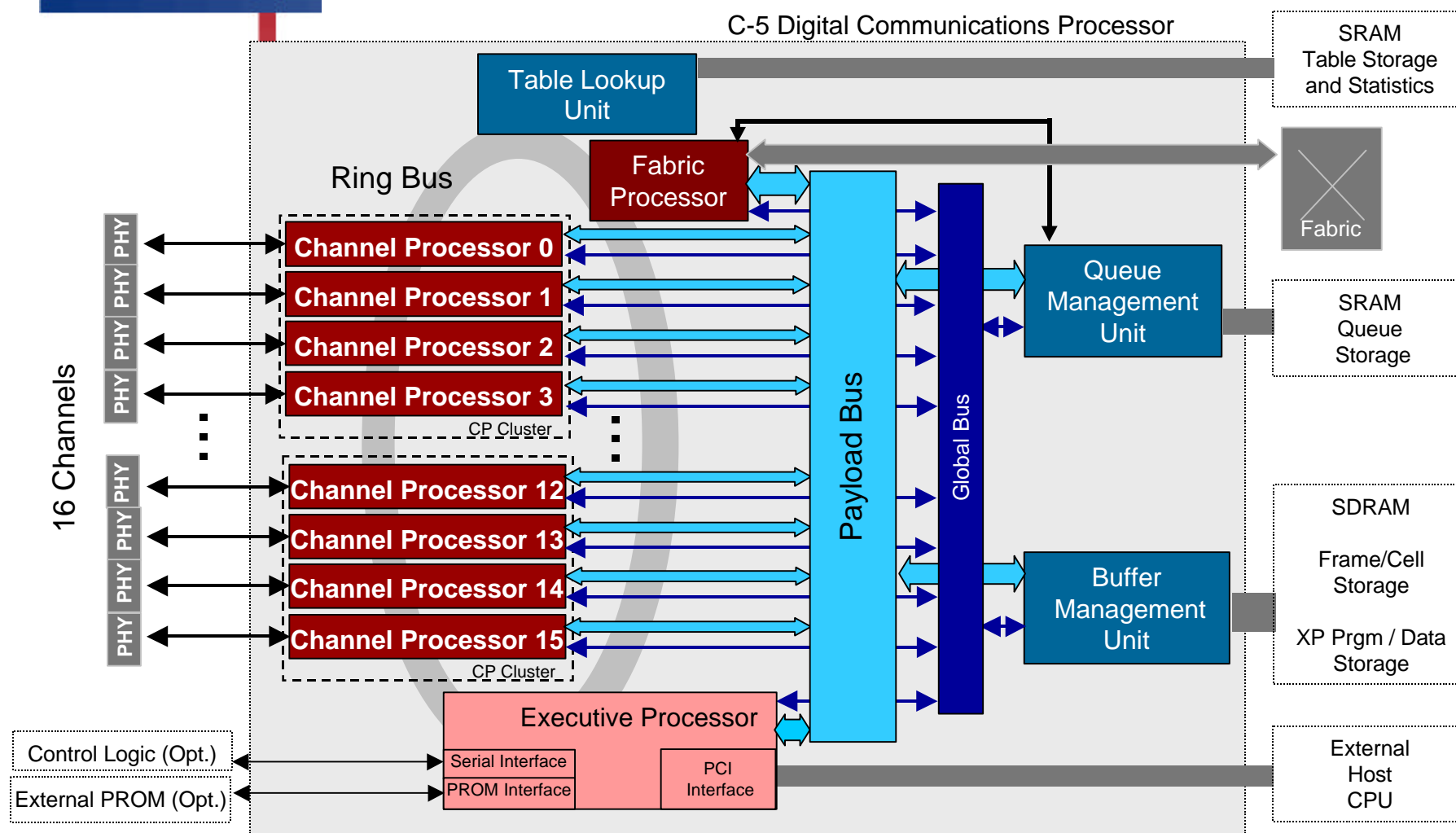
Traffic Classification
Policy Enforcement
VPN & MPLS Services
Quality of Service
Switching / Routing
Interworking, ...

Physical Layer

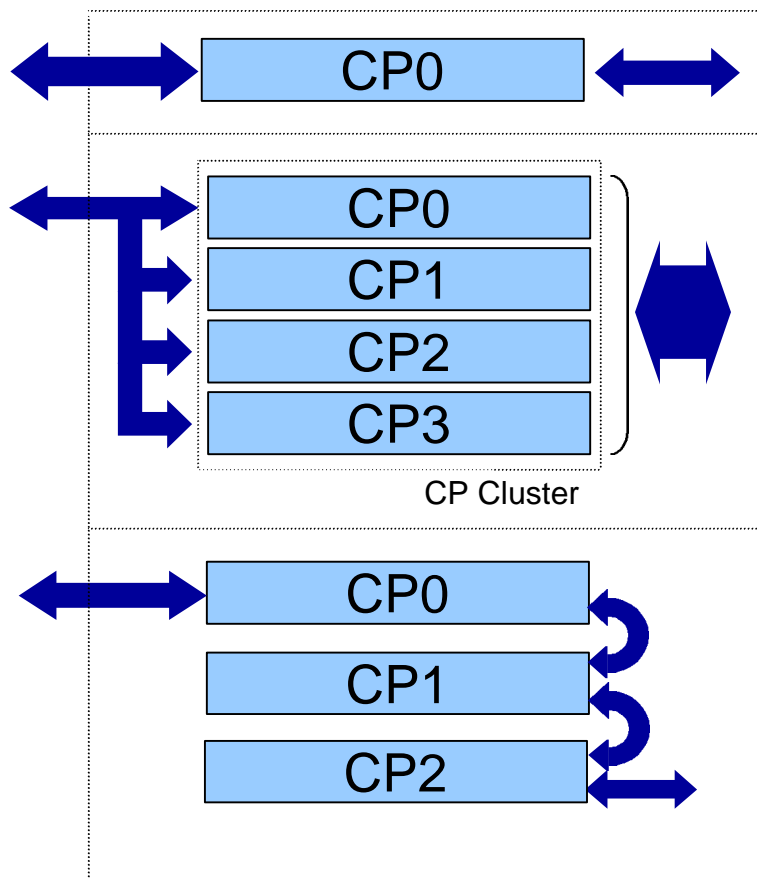
(DS-1 through OC-48 rates)
T/E-Carrier, Ethernet, SONET,
FR, POS, ATM, DWDM, Fibre Channel



C-5 DCP Functional Block Diagram



Channel Processors: Scale with Parallel and / or Pipelined Processing



- Single CP processes full duplex wire-speed data up to 155Mbps
- CP Aggregation scales bandwidth
 - CPs organized into parallel clusters (4 CPs per cluster)
 - Built-in sequencing scheme maintains simple programming
- CP Cascading scales processing
 - CPs linked for pipelined processing on single data stream
 - Internal data recirculation enables flexible CP assignment

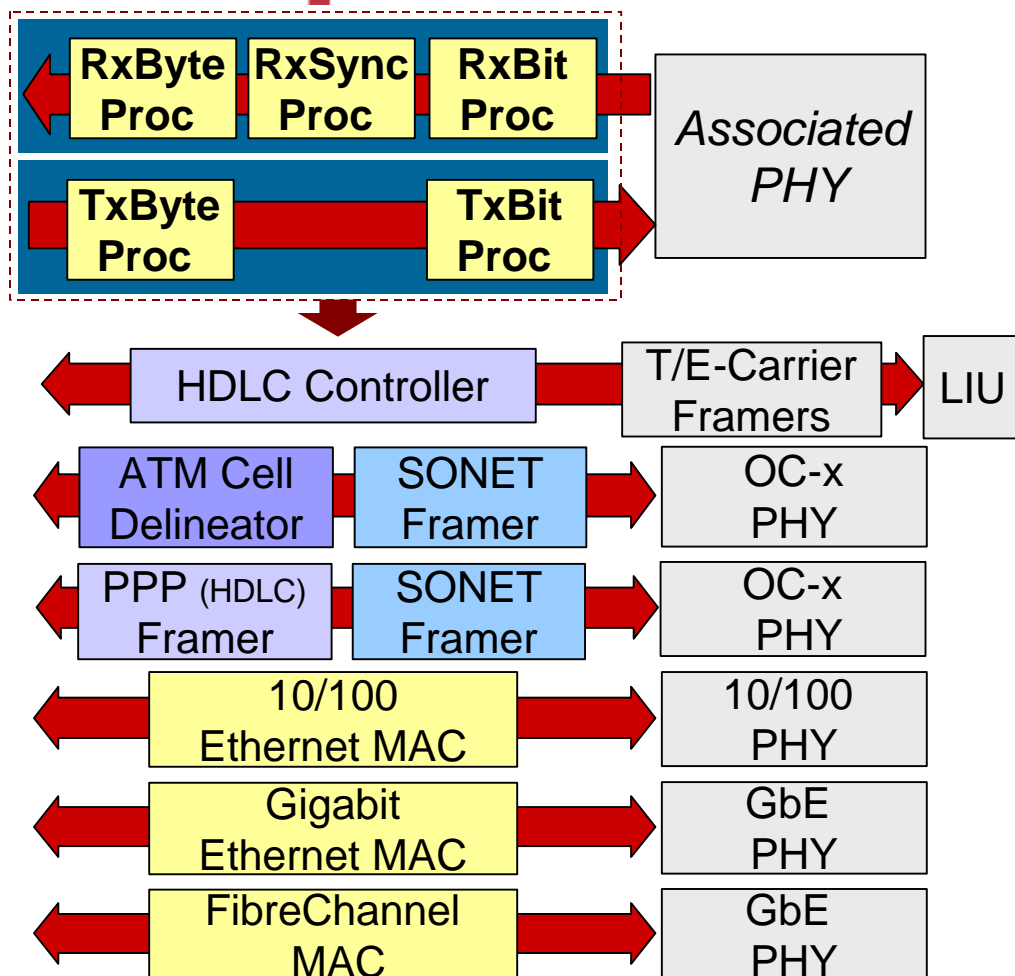


The diagram illustrates the internal components and data flow of the QEMU architecture. A central **Channel Processor RISC Core** (CPRC) is connected to **Instruction Memory**. Below the CPRC are the **RxSDP Receive Serial Data Processor** and the **TxSDP Transmit Serial Data Processor**. To the right of the CPRC are the **Extract Space** and **Merge Space**, which interface with the **Data Memory**. A horizontal bus connects the CPRC, Instruction Memory, and Data Memory. A vertical bus connects the CPRC, Extract Space, Merge Space, and Data Memory. A dashed red line represents the **Data** path from RxSDP to Data Memory, and a solid red line represents the **Control** path from RxSDP to Extract Space. A yellow box labeled **Descriptor to QMU** is shown at the top. A red arrow points from the CPRC to the Descriptor to QMU box. A red arrow points from the RxSDP to the Descriptor to QMU box. A red arrow points from the Data Memory to the **Data DMA (BMU via payload bus)**.

- Harvard Architecture
- Quad-ported IMEM (24K)
- Quad-ported DMEM (48K)
- Optimized instruction set for networking applications

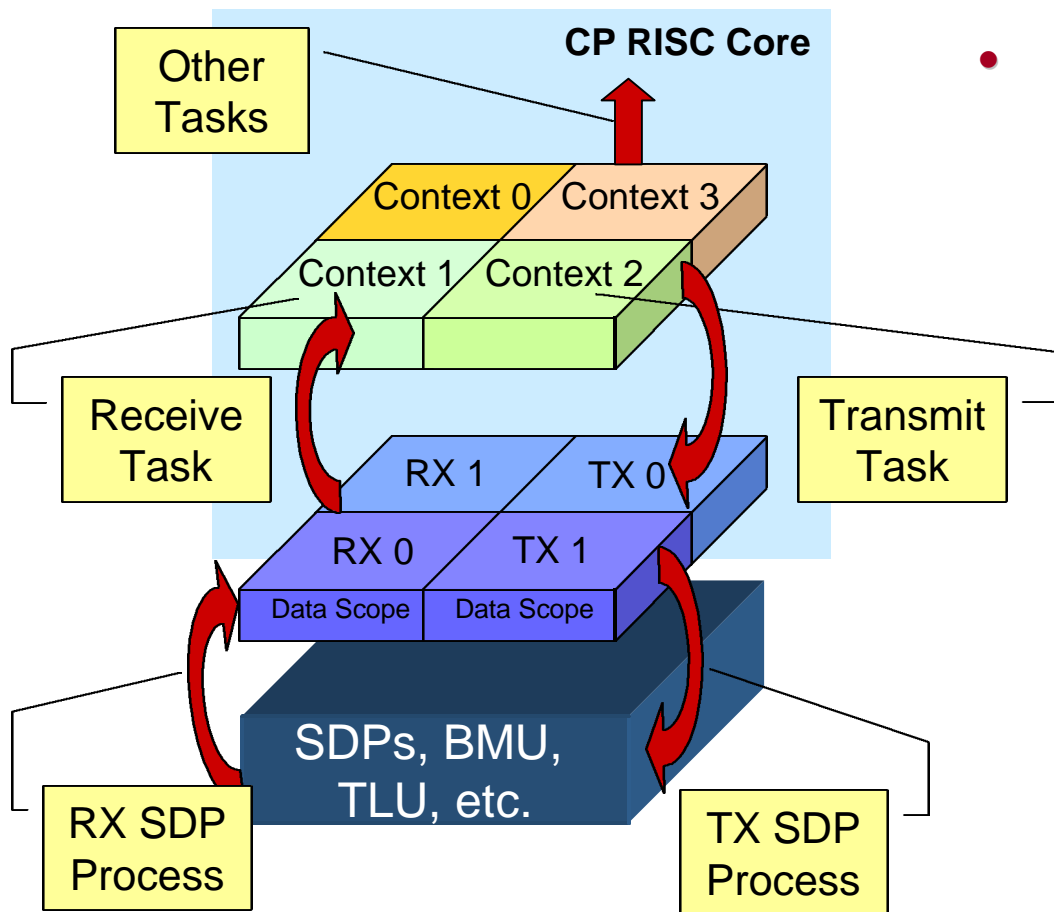
- Bit and byte-level micro-sequencers
- Programmable field parsing / extraction / insertion / deletion
- CRC validation & calculation

Serial Data Processors



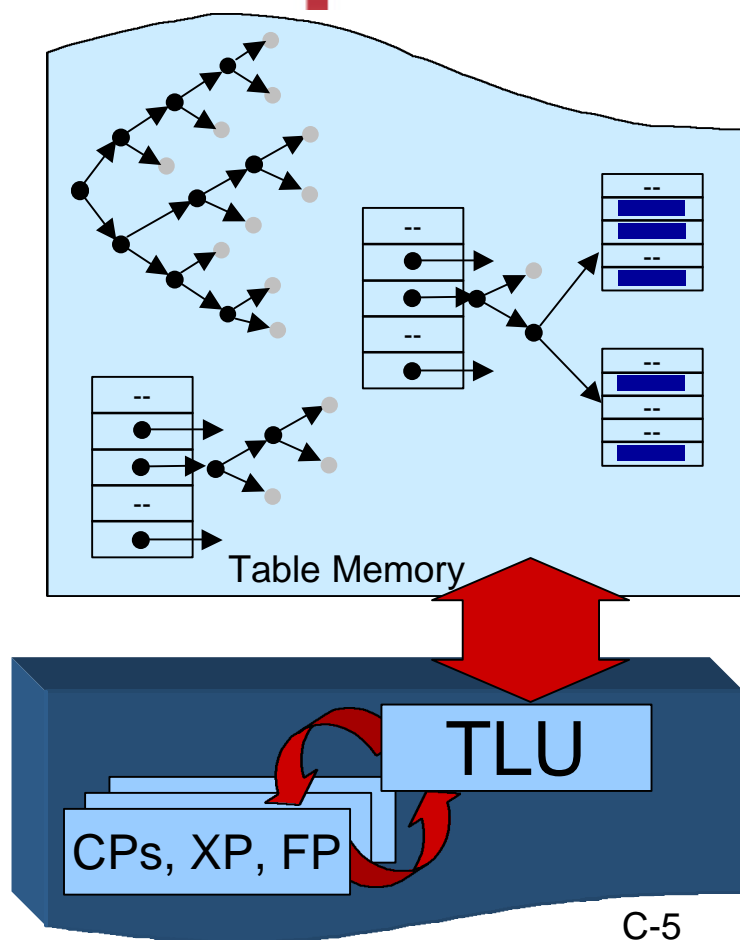
- Configurable pin logic for connection to a wide variety of physical interface types
- On-chip functional integration
 - 10/100 Ethernet MACs
 - GbE MACs
 - OC-3/12 SONET framers
 - HDLC Controllers
 - ATM Cell Delineation
 - FibreChannel
- Adaptable to future and / or proprietary interfaces

Channel Processor RISC Core



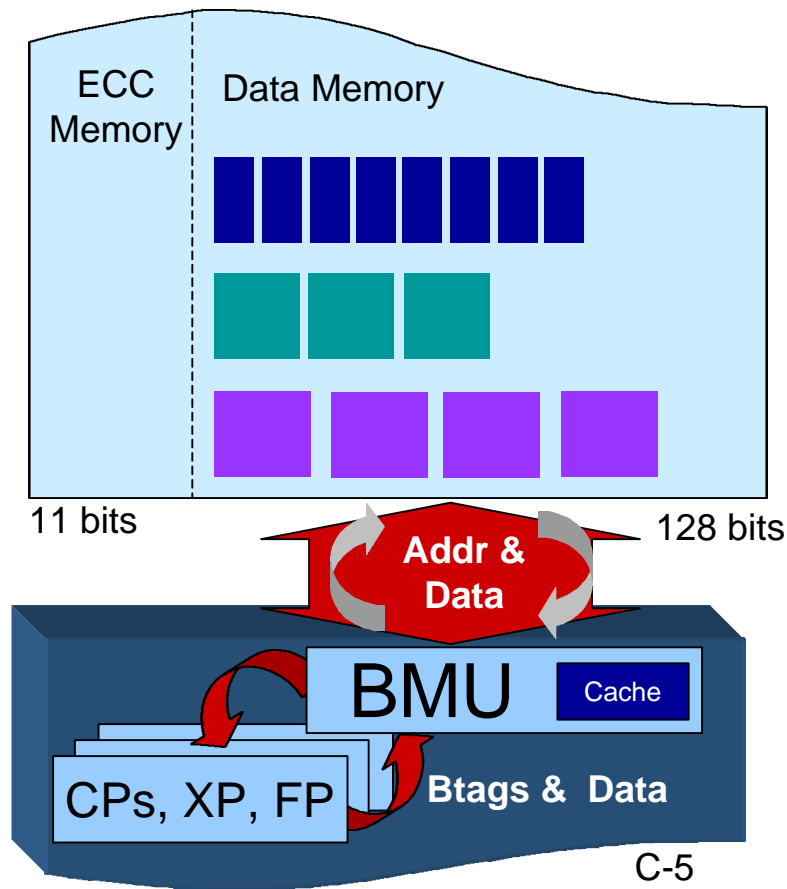
- Multi-context RISC architecture
 - 4 independent register sets for fast context switching
 - 4 independent data scopes for multi-task performance
 - Extract, merge memory and queue status registers for header & data management
 - 64-bit event register for efficient polling

Table Lookup Unit: Specialized Co-Processor for Table Manipulation



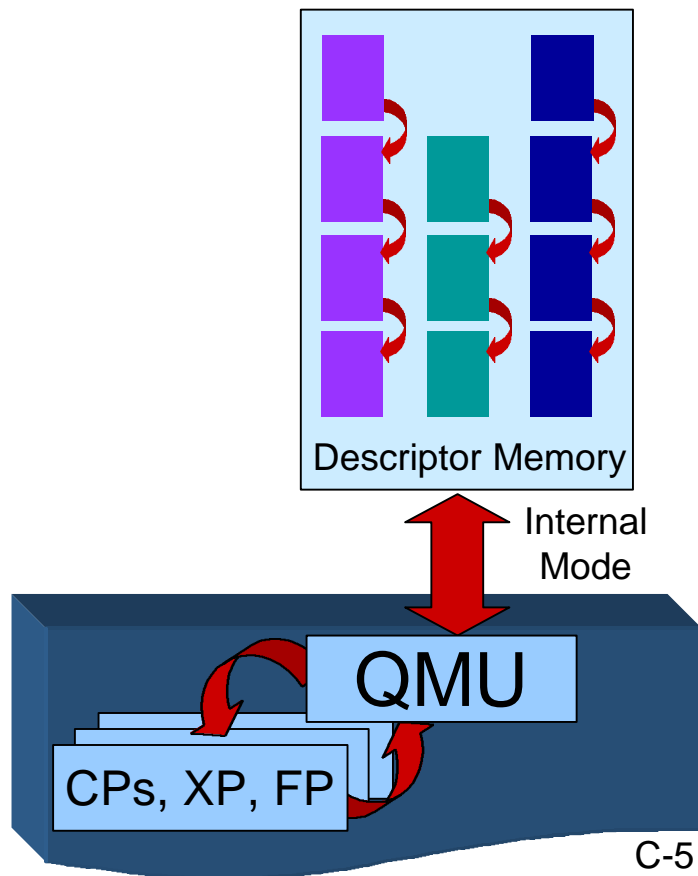
- Implements complex L2/3/4+ lookups
 - hash, exact match, longest prefix match, etc.
- Supports multiple lookup algorithms simultaneously
- Internally pipelined
- Up to 133M lookups/sec (max)
- Tables implemented in 64 bit, 133MHz ZBT SRAM
 - Up to 64MB in four banks

Buffer Management Unit: Specialized Co-Processor for Buffer Manipulation



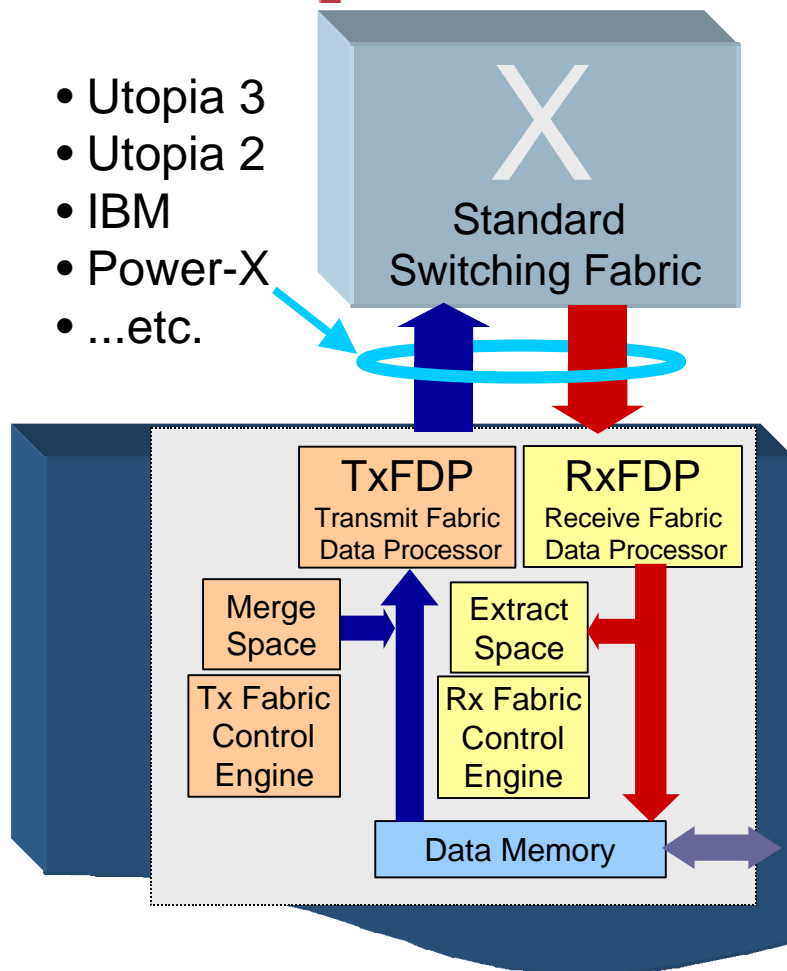
- Implements simple buffer tag scheme
 - Supports multicast buffer counters
- Up to 16 Gbps maximum bandwidth
- Up to single bank SDRAM (128MB)
- Built-in error-correction / detection
 - 139-bit interface, up to 125MHz (128 bits data, 9 bits ECC)
- Configures up to 30 different pools
 - Buffer sizes from 64 to 64K bytes
 - Up to 64K buffers per pool

Queue Management Unit: Specialized Co-Processor for Queue Manipulation



- Implements programmable queuing mechanisms
 - Automated multicast elaboration
- Built-in thresholds for multi-class buffer management
 - Up to 4 usage pools
 - Separate allowance & limit per pool
- Implements up to 512 queues
 - Flexible per processor allocation
 - Up to 16,384 descriptors
- Descriptors stored in 32-bit, ZBT SRAM (128K max) at 1/2 core clock frequency

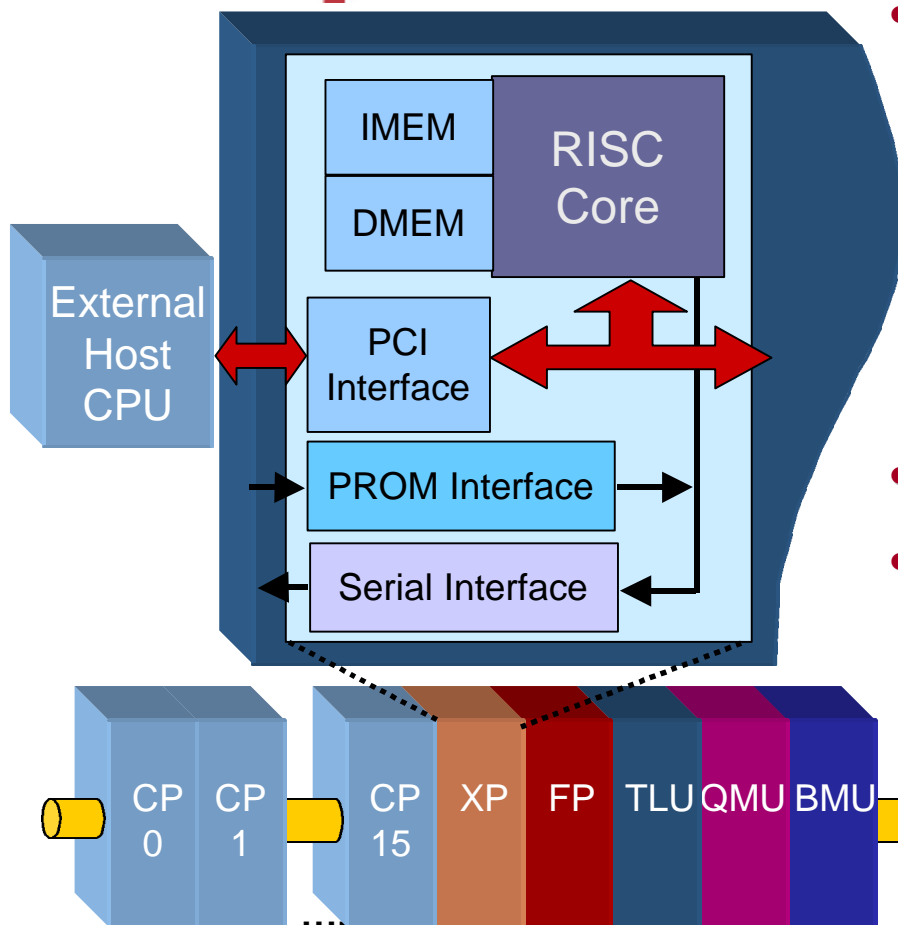
Fabric Processor: Specialized Co-Processor for Fabric Connection



- Utopia 3
- Utopia 2
- IBM
- Power-X
- ...etc.

- Flexible support for many interfaces
 - Utopia 2 and Utopia 3
 - Glueless for some industry fabrics
 - Configurable for proprietary fabrics
- Programmable fabric parameters
- Flow and congestion control
- Segmentation and re-assembly
- >15M packets/cells per second
- Integrated scheduling up to 128 Q's
- 3.2 Gbps full-duplex maximum
 - 100Mhz, 64bits (32bit Tx / 32bit Rx)

Executive Processor: Specialized Co-Processor for Auxiliary Management

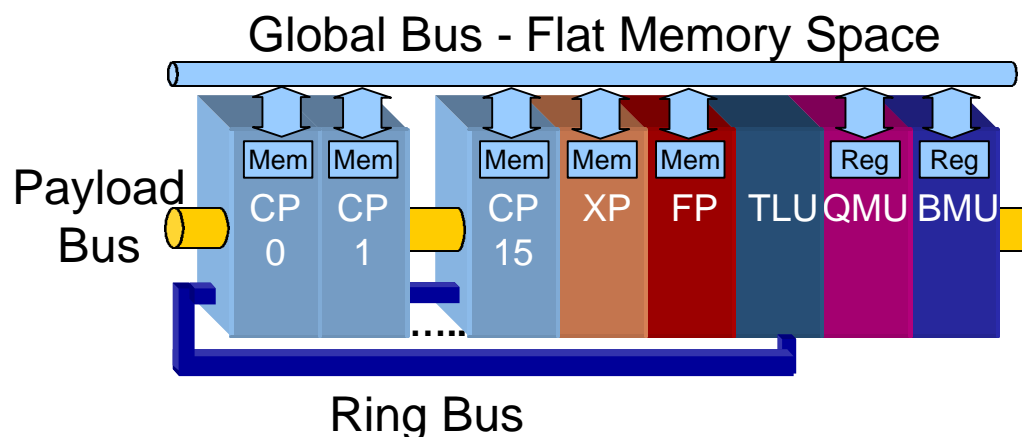


- Auxiliary processor for internal chip management
 - Reset, initialization, configuration
 - External host communication
 - Statistics harvesting
 - Table maintenance, etc.
- Standard RISC instruction subset
- External interfaces
 - 32-bit, 33/66MHz PCI bus (Host)
 - Optional Serial PROM (Program)
 - 2-wire, configurable bi-directional serial bus (I2C-like or MDIO for LEDs, PHY control, etc.)

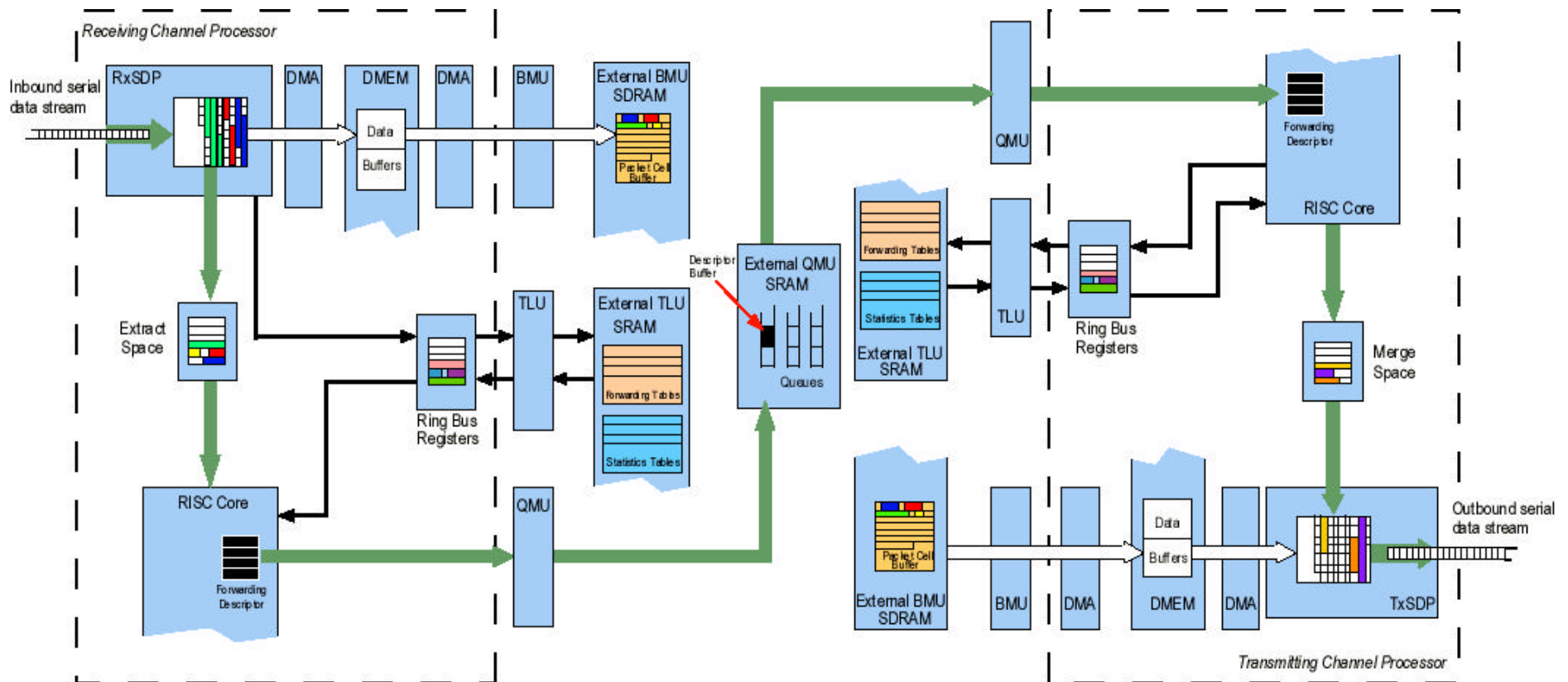
Internal Interconnect

	Bandwidth	Bus Width	Transfer Size
Payload Bus	~35 Gbps	128 bits	64 bytes
Ring Bus	~22 Gbps	64 bit	8 bytes
Global Bus	~4 Gbps	128 bits	16 bytes

- Three optimized buses separate control / data:
 - Payload Bus: data movement
 - Ring Bus: controlled latency transfers
 - Global Bus: general inter-processor messaging
- Global bus provides flat memory space across all processor memories



Application Example: Channel Forwarding Operation





C-5 DCP Methodology

- Time-to-market driven
 - few in-house tools
- Industry standard tools:
 - logic synthesis
 - place and route
 - verification
- Mixture of semi- custom and custom
 - 16.4M semi- custom x-tors, 40M custom x-tors
- Semi- custom
 - control structures
- Custom design where highest benefit
 - SRAMs, CAMs, buses, pads, clocks, ECC, etc.



C-5 DCP Summary

- 200 Mhz
- 17 RISC Cores
- 32 Serial Data Processors
- 5 Co-Processors
- Integrated memory and multiple buses
- Approximately 56M Transistors
- 0.18 um CMOS process
- 1.8V VDD
- 838 pin BGA Package
- JTAG Compliant